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March 27, 2015

Marlene H. Dortch, Secretary
Federal Communications Commission
445 Twelfth Street, SW
Washington, DC 20554

Re: Written *Ex Parte*: *Terrestrial Use of the 2473-2495 MHz Band for Low-Power Mobile Broadband Networks* – IB Docket No. 13-213

Dear Ms. Dortch:

Globalstar, Inc. ("Globalstar") through its outside counsel hereby submits into the record the attached response of Roberson and Associates, LLC ("Roberson and Associates"), to the March 20, 2015 report from the Bluetooth Special Interest Group ("Bluetooth SIG") on recent demonstrations of Globalstar's Terrestrial Low Power Service ("TLPS") technology.[1] Roberson and Associates' team of technical experts participated in Globalstar's TLPS demonstrations at the Commission's Technology Experience Center ("TEC") on March 6, 2015, and observed the Bluetooth SIG's demonstration on the same date. As Roberson and Associates describes in the attached analysis, rather than show a detrimental impact on Bluetooth devices, the compatibility demonstrations at the TEC confirmed that TLPS will be a good neighbor to Bluetooth operations within the unlicensed ISM band at 2400-2483.5 MHz.

The attached report from Roberson and Associates includes the following information and findings, among other things:

- The Bluetooth speaker demonstrations performed by Globalstar, observed by both Commission and Bluetooth representatives, showed no audio degradation and clearly contradict the Bluetooth SIG's assertion that there was "too much interference in the demonstration room even without TLPS to hear clear audio."[2]

- The Bluetooth SIG's recorded audio samples of a violin concerto (with and without TLPS), as processed by a Bluetooth Low Energy ("BLE")-equipped hearing aid, showed no observable difference in audio quality when played back to observers at the TEC; any increase in the packet error rate for this device was not discernible to listeners in the real world and could only be detected with special purpose measurement equipment.

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1 *See TLPS and Bluetooth Demonstrations FCC Technology Center – March 06, 2015* attached to *Ex parte* filing of Bluetooth SIG, IB Docket No. 13-213 (Mar. 20, 2015).

2 *Ex parte* filing of Bluetooth SIG, IB Docket No. 13-123, at 2 (Mar. 20, 2015).

- The portion of the Bluetooth SIG's demonstration utilizing Bluetooth-enabled "Smart Lighting" devices suffered from fundamental flaws, including (i) the use of exposed circuit boards not ready for commercial deployment, (ii) neglecting to enable an "acknowledgement" mechanism in these devices, undercutting their reliability, and (iii) an unstructured measurement approach relying on error-prone and contemporaneously contested visual observation of multiple devices.

- At the Commission's encouragement, Globalstar and the Bluetooth SIG reached agreement on basic conditions and parameters for the TLPS demonstrations prior to the event, including access point power levels, the number of client devices attached to each access point, and the traffic load at each access point.

- Contrary to the Bluetooth's concerns about traffic volume, the level of traffic on Channels 1, 6, 11, and 14 (TLPS) (a continuous rate of 3.7 Mbps per access point) was greater than the level of traffic requested by the Bluetooth SIG in its Test Plan submitted to the Commission.

- The Bluetooth SIG had ample time and opportunity to conduct its demonstrations, given that (i) its three-and-a-half hour demonstration on March 6 lasted as long as *all* of Globalstar's demonstrations at the TEC, including those not addressing Bluetooth, and (ii) the TEC was fully available for additional demonstrations on March 9 and 10, 2015.

As Roberson and Associates concludes, there is no meaningful evidence supporting the Bluetooth SIG's claim that TLPS would have a detrimental effect on Bluetooth devices. Instead, the TLPS demonstrations at the TEC confirm that TLPS does not have any effects on Bluetooth that will be discernible to real-world consumers and end users. Given these demonstration results, the Commission should expeditiously adopt its proposed rules allowing Globalstar to provide this low-power terrestrial mobile broadband service in its own licensed spectrum at 2483.5-2495 MHz and adjacent, unlicensed spectrum at 2473-2483.5 MHz.[3] American consumers will benefit significantly from the provision of TLPS across 22 megahertz in the 2.4 GHz band.

Respectfully submitted,

/s/ *Regina M. Keeney*
Regina M. Keeney

cc: Mark Settle

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[3] *Terrestrial Use of the 2473-2495 MHz Band for Low-Power Mobile Broadband Networks; Amendments to Rules for the Ancillary Terrestrial Component of Mobile Satellite Service Systems*, Notice of Proposed Rulemaking, 28 FCC Rcd 15351 (2013).

Roberson and Associates, LLC
Technology and Management Consultants

Review of the Bluetooth SIG Ex Parte Filing of March 20, 2015 Titled: "Further Comments and Detailed Report from TLPS & Bluetooth Demonstrations FCC Technology Center - March 6, 2015"

Prepared for Globalstar, Inc., by:

Roberson and Associates, LLC
Chicago, Illinois

Authors:

Kenneth J. Zdunek, Ph.D.
Michael Needham
Nat Natarajan, Ph.D.
Edward Porrett

Date: March 27, 2015

Review of the Bluetooth SIG ex parte filing of March 20 Titled:
"Further Comments and Detailed report from TLPS & Bluetooth Demonstrations FCC Technology Center - March 6, 2015"

1. A Roberson and Associates team of technical experts participated in the Globalstar TLPS demonstrations at the FCC Technology Experience Center (TEC) on March 6, 2015 and also observed the Bluetooth SIG's measurements and demonstrations. Roberson and Associates has subsequently reviewed the Bluetooth SIG ex parte filing of March 20, 2015 regarding those demonstrations, and provides the following clarifications, responses, and corrections to statements made in that filing.

   Level of Access Point Traffic

2. Bluetooth SIG asserts that the level of traffic on the channel 1, 6, 11, and 14 (TLPS) access points was very low (3.7 Mbps) when compared to the maximum possible for the access points provided by Globalstar. According to the Bluetooth SIG, the maximum possible for the access points was 200 Mbps.

   In response, Roberson and Associates notes that in planning for the demonstrations at the FCC, the FCC encouraged Bluetooth SIG and Globalstar to coordinate their demonstrations of Bluetooth devices. The two parties reached agreement on basic test conditions, including power levels, the number of clients attached to each access point, and the traffic load at each access point. As part of this cooperative effort, Globalstar agreed to the Bluetooth SIG's use of Globalstar's network of access points, so that the Bluetooth SIG would not have to bring or install its own access points for its demonstration. While the number of access points and associated power levels were probably excessive for the small amount of space at the TEC room, these facts were conservative for Globalstar and the venue was otherwise well suited to the demonstrations.

   We further observe that the amount of traffic generated by Globalstar's access points was, in fact, greater than the level of traffic requested by the Bluetooth SIG itself in its Test Plan submitted to the FCC[1] and in its discussions at the TEC with Roberson and Associates. In the Bluetooth SIG Test Plan, Bluetooth SIG specified that "…a streaming service such as Video/Netflix [would be] running" during its demonstration. In order to comply with this request (which was reiterated in discussions at the TEC), Globalstar provided a continuous 3.75 Mbps data stream to a client device on each access point, equivalent to a high definition video source. Typically, Netflix streams 1080p resolution at 3.0 Mbps. Finally, we note that

[1] *Globalstar TLPS Test Plan Overview*, Dated 2015-03-04, Document Number TLPS.TP.1.0.0r00, Group Prepared by Bluetooth SIG, http://apps.fcc.gov/ecfs/document/view?id=60001039997.

the effective maximum data rate capability of the access point-client pairs employed by Globalstar in the demonstration environment was 50 Mbps, not 200 Mbps as claimed by Bluetooth SIG.

3. Bluetooth SIG asserts that "specific media files were used by those operating the TLPS setup for the Bluetooth demonstrations, files which may have produced a lower level of traffic."

   Roberson and Associates believes that the Bluetooth SIG's concern is completely unfounded. The AT4 Wireless test tool streamed data at a continuous rate of 3.75 Mbps. This data rate was displayed in real time by monitoring software visible on the Wi-Fi client devices, was observed by the Bluetooth SIG participants witnessing the demonstration, and was recorded by the AT4 Wireless performance monitoring software. This data has been made available to all participants, including the FCC and Bluetooth SIG.

   Globalstar Stereo Speaker Demonstration

4. Bluetooth SIG asserts that the Globalstar demonstration that unequivocally showed no audio degradation either with or without TLPS active was "suspicious," since the Bluetooth Group observed "too much interference in the demonstration room even without TLPS to hear clear audio."

   First, Globalstar and Roberson and Associates are unaware of any feedback from the Bluetooth SIG regarding this situation during either the demonstration set-up process or the TLPS-Bluetooth demonstrations. It was not until two weeks after the demonstration that Bluetooth SIG claimed there was too much interference at the TEC for Bluetooth-enabled speakers to operate successfully. Globalstar's Bluetooth speaker demonstrations, observed by both FCC and Bluetooth SIG representatives, showed no audio degradation and clearly contradict this Bluetooth SIG assertion. The Bluetooth SIG did not dispute Globalstar's findings at this demonstration. Additionally, while Globalstar has disclosed all of its demonstration data to all parties participating in the demonstrations at the TEC, the Bluetooth SIG has failed to disclose its collected data and refuses to release its own audio files, which were a central part of its presentation.

   In its TLPS-Bluetooth demonstration, Globalstar used popular, off-the-shelf Bluetooth speakers, and there is nothing "suspicious" about Globalstar's showings. The access point traffic and power levels were exactly the same for the Globalstar and Bluetooth SIG demonstrations, as was witnessed by the demonstration observers. Roberson and Associates personnel also observed that during the Bluetooth SIG's measurements and demonstrations, multiple simultaneous Bluetooth devices were in operation. This factor suggests that the purported impact on Bluetooth operations may have been self-generated and due to other Bluetooth devices (particularly since the Bluetooth SIG's speakers were driven by open unshielded circuit boards).

Bluetooth Low-Energy (BLE) Equipped Hearing Aids

5. Bluetooth SIG performed measurement demonstrations of what it described as BLE equipped hearing aids. Bluetooth SIG first operated these devices with IEEE 802.11n access points operating on channels 1, 6, and 11, and then operated them with access points operating on channels 1, 6, 11, and channel 14 (TLPS). According to Bluetooth SIG, since the packet error rate allegedly increased from approximately 10% to approximately 20% with the activation of TLPS, the performance degradation to a BLE-equipped hearing aid due to TLPS is unacceptable. Bluetooth SIG also reported that the number of audio discontinuities increased from 12 (without TLPS) to 14 (with TLPS operational) in the approximate 2½ minute audio playback sequence.

   In response, Roberson and Associates observes that when the two audio samples of a lengthy violin concerto – with and without TLPS active – were played back to the observers at the FCC TEC, there was no perceptible difference in audio quality between these samples. Due to the robustness of the BLE protocol, the increase in packet error rate was not discernible to the listeners. Similarly, due to the robust nature of the BLE audio protocol, no apparent difference in the number of short drop-outs in the audio samples was detected by the listeners between the non-TLPS and TLPS scenarios. Any negative effect from TLPS could only be detected with special purpose measurement equipment. Roberson and Associates concludes that in a real-world environment, there is no perceptible difference to end users between BLE audio with or without TLPS.

   With respect to the packet error rate, it is important to note that initially at the demonstration, Bluetooth SIG's representatives stated that there would only be effects perceptible to end users if the packet error rate was above 30%. This threshold was then lowered to 20% at the time of their presentation of their results. Following the demonstration, however, the Bluetooth SIG now claims that any packet error rate in excess of 10% - which happens to be the baseline error rate experienced in its demonstration - would result in "significant audio disruption" for the user.

   Regarding an acceptable packet error rate limit, no authoritative statement on a packet error rate limit for acceptable audio quality has been able to be found in the Bluetooth documentation. With regard to Error Handling, the Bluetooth Core Specification states:[2]

   > "The quality of the voice in an error-prone environment [for Bluetooth packet types where no error correction is used] then depends on the robustness of the voice coding scheme and, … the retransmission scheme. CVSD [a voice coding method], in particular, is rather insensitive to random bit errors, which are experienced as white background noise.

[2] *See* BLUETOOTH SPECIFICATION Version 4.2 [Vol 2, Part B] page 213, ERROR HANDLING, accessed at https://www.bluetooth.org/en-us/specification/adopted-specifications.

> "The voice payload [for certain other Bluetooth packet types] [is] protected by a 2/3 rate FEC. [Forward Error Correcting Code]…The [Bluetooth] HV1 packet is protected by a 3 bit repetition FEC."

The only conclusion that can be drawn from the Bluetooth specification is that packet error rate alone does not determine the resultant voice quality and user experience. The voice coding method and error correction used, which contribute to the robust nature of the Bluetooth protocol, have a significant impact on the resultant voice quality, and these factors must be known before any statement can be made about the relationship between packet errors and audio quality. Based on the audio samples played back during the Bluetooth SIG demonstration, it is clear that packet error rate alone is not a good measure of audio quality.

Roberson and Associates further notes that BLE-equipped hearing aids could not be found on the Bluetooth SIG websites listing the BLE-equipped products that currently are commercially available.[3] Thus, it appears doubtful that BLE standards-based hearing aids are actually commercially available today. In fact, a website related to hearing and hearing aids states that Bluetooth-equipped hearing aids are not on the market since the full Bluetooth standard cannot be implemented in these devices due to battery (power) limitations.[4] Jason Galster of Starkey Hearing Technologies has stated that "[w]hile useful for low-power applications, the Bluetooth 4.0 protocol does not allow for transmission of audio."[5] (BLE is optimized for low power consumption and intermittent transfer of short data bursts rather than for continuous operation.) Thus, it appears highly likely that the hearing aids demonstrated at the FCC TEC, which supposedly used the BLE standard, are actually based on a proprietary protocol. It is unknown why the Bluetooth SIG chose to demonstrate this product rather than significantly more common products such as Bluetooth-equipped heart rate (pulse) monitors or a Bluetooth-equipped computer mouse.

Bluetooth Smart Lighting Demonstration

6. Bluetooth SIG also performed a demonstration of five Bluetooth-based mesh network devices that would be used for turning lights on and off and other home-based wireless control applications ("Smart Lighting Demonstration"). In its March 20 ex parte, the Bluetooth SIG stated that over two sets of 50 transmissions in this Smart Lighting Demonstration, the number of single device operational failures increased following the

[3] *See Bluetooth Smart and Smart Ready Products Now Available*, Bluetooth, http://www.bluetooth.com/Pages/Bluetooth-Smart-Devices-List.aspx (last visited Mar. 27, 2015); *Bluetooth Smart and Smart Ready Products Now Available*, Bluetooth, http://www.bluetooth.com/Pages/Bluetooth-Smart-Devices-List.aspx#SmartReady (last visited Mar. 27, 2015).

[4] *See* Mandy Mroz, *Hearing Aids and Bluetooth Technology*, Healthy Hearing (Nov. 18, 2014), http://www.healthyhearing.com/help/hearing-aids/bluetooth.

[5] Jason Galster, *Wireless Technology is Constantly Changing – Are you keeping up?*, Starykey Hearing Technologies, https://starkeypro.com/ pdfs/technical-papers/Wireless_Technology_is_Constantly_Changing_White_Paper.pdf.

activation of a TLPS access point on channel 14 (access points operated on channels 1, 6, and 11 during both sets of transmissions). Simultaneous with the Smart Lighting demonstration, Bluetooth "classic" traffic channels were active via a Bluetooth A2DP connection between a Smartphone and speakers.

Roberson and Associates observes that, based on the Bluetooth SIG's reported data, the failure rate while channels 1, 6, and 11 alone were active (along with the Bluetooth audio connection) was 6% and 8% (for lighting color changes and on-off operation, respectively). It is our view that this rate of operational failures, due to operation of channels 1, 6, and 11 alone, calls into question the reliability of the technology used, notwithstanding additional measureable degradation, if any, caused by TLPS. Since mesh technology has not yet been standardized by the Bluetooth SIG, it is unclear why the Bluetooth SIG chose to use this technology in its demonstration.

Roberson and Associates further notes that besides not being included in the original Bluetooth SIG Demonstration Plan submitted to the FCC,[6] the Smart Lighting devices used for this demonstration consisted of exposed circuit boards apparently not packaged for commercial distribution to consumers. It is unclear what effect the exposed nature of this equipment would have on the susceptibility of these devices to Wi-Fi transmissions or other interference sources. In any event, there are a number of factors that could explain the failure of these devices to achieve reliable operation with only Wi-Fi channels 1, 6, and 11 in use. One likely contributor to this baseline failure rate was the absence of an "acknowledgement" mechanism that could have been included in these devices, an equipment issue confirmed by the Bluetooth SIG representative conducting this demonstration. This representative also noted that such a Smart Lighting demonstration would preferably be conducted with many more devices than were deployed at the FCC TEC, since a mesh network functions better with more participating devices.

Finally, the Bluetooth SIG's recording of the Smart Lighting demonstration results were unstructured and relied on error-prone visual observation of multiple devices. Even when the Bluetooth SIG representative was attempting to determine a baseline failure rate with access points operating only on Wi-Fi channels 1, 6 and 11, the demonstration observers, including FCC personnel, disputed the recorded failures at the time of these measurements. The Bluetooth SIG representatives disagreed with this feedback, however, and did not attempt to correct their recorded failure rate, or re-start this portion of the demonstration in order to eliminate any disputed measurements.

Time Allocated for the Bluetooth SIG to Perform the Demonstrations

[6] See *Globalstar TLPS Test Plan Overview*, Dated 2015-02-27, Document Number TLPS.TP.1.0.0r00, Group Prepared by Bluetooth SIG, http://apps.fcc.gov/ecfs/document/view?id=60001037469.

7. Bluetooth SIG asserted that "[o]ther Bluetooth SIG defined demonstration scenarios were not executed considering the short amount of time allocated for the Bluetooth SIG to perform these demonstrations."

   In response, Roberson and Associates notes that the Bluetooth SIG's demonstrations were conducted in about 3½ hours (from approximately 1:30-5 PM) on March 6. This was approximately the same amount of time utilized by the Globalstar team on Friday, March 6 and Monday, March 9, to perform and report on its Bluetooth and Wi-Fi demonstrations. Two additional demonstration periods – on the afternoon of March 9 and all day on March 10 – were available to the Bluetooth SIG to coordinate with CableLabs for their demonstration scenarios. (The Bluetooth SIG also fails to acknowledge that it had approximately one month to prepare for the demonstration and four days for set-up at the FCC TEC.) The Bluetooth SIG did not indicate during the demonstration that it lacked sufficient time to conduct its demonstrations. Since the Bluetooth SIG did not take advantage of the opportunity for further demonstrations on March 9 and March 10, it is disingenuous for it to claim now that additional demonstration scenarios were not executed due to time limitations.

Summary

8. Roberson and Associates observed the Bluetooth SIG's demonstrations at the FCC TEC on March 6 and has reviewed the results described in the Bluetooth SIG's recent ex parte filing. There is no basis for the Bluetooth SIG's conclusion that TLPS would have a significant detrimental impact on Bluetooth device operations. In addition, the Globalstar team's successful operation of commonly used, commercially available Bluetooth and Bluetooth Low-Energy devices in the presence of IEEE channels 1, 6, 11, and 14 (TLPS) at the TEC on March 6 directly contradicts the Bluetooth SIG's conclusion.

APPENDIX: COMPANY PROFILE

Profile: Roberson and Associates, LLC

Roberson and Associates, LLC, is a technology and management consulting company serving government and commercial customers that provides services in the areas of RF spectrum management, RF measurements and analysis, strategy development, and technology management. The organization was founded in 2008 and is composed of a select group of individuals with corporate and academic backgrounds from Motorola, ARRIS, Bell Labs (AT&T, Bellcore, Telcordia, Lucent, Alcatel-Lucent), Cisco, Google, IBM, IITRI (now Alion), ITW, NCR, Nokia, S&C Electric, independent consulting firms, and Illinois Institute of Technology. Together the organization has over 400 years of high technology management and technical leadership experience with a strong telecommunications focus.

Profiles: Roberson and Associates, LLC, Staff

Dennis Roberson, President and CEO

Mr. Roberson is the Founder, President and CEO of Roberson and Associates, LLC. In parallel with this role he serves as Vice Provost for Research, and Research Professor in Computer Science at Illinois Institute of Technology where he has responsibility for IIT's corporate relationships including IIT's Career Management Center, Office of Compliance and Proposal Development, Office of Sponsored Research and Programs, and Technology Transfer efforts. He also supports the development and implementation of IIT's Strategic Plan, the development of new research centers, and the successful initiation and growth of IIT related technology-based business ventures. He is an active researcher in the wireless networking arena and is a co- founder of IIT's Wireless Network and Communications Research Center (WiNCom). His specific research focus areas include dynamic spectrum access networks, spectrum occupancy measurement and spectrum management, and wireless interference and its mitigation and of which are important to the Roberson and Associates mission. He currently serves on the governing and / or advisory boards of several technology-based companies. Prior to IIT, he was EVP and CTO at Motorola and he had an extensive corporate career including major business and technology responsibilities at IBM, DEC (now part of HP), AT&T, and NCR. He is and has been involved with a wide variety of Technology, Cultural, Educational and Youth organizations currently including the FCC Technical Advisory Council and Open Internet Advisory Committee, the Commerce Spectrum Advisory Committee, and the National Advisory Board for the Boy Scouts of America and its Information Delivery Committee, and the Board of HCJB Global. He is a frequent speaker at universities, companies, technical workshops, and conferences around the globe. Mr. Roberson has BS degrees in Electrical Engineering and in Physics from Washington State University and a MSEE degree from Stanford.

Ken Zdunek, Vice President & CTO

Dr. Zdunek is Vice President and the Chief Technology Officer of Roberson and Associates. He has over 30 years of experience in wireless communications and public safety systems.

Concurrently he is a research faculty member in Electrical Engineering at the Illinois Institute of Technology, in Chicago, Illinois, where he conducts research in the area of dynamic spectrum access and efficient spectrum utilization, and teaches a graduate course in wireless communication system design. He is a Fellow of the IEEE, recognized for his leadership in integrating voice and data in wireless networks. He was recently a contributor to the FCC's Emergency Response Interoperability Center Public Safety Advisory Committee (ERIC PSAC). Prior to joining Roberson and Associates, he was VP of Networks Research at Motorola. Dr. Zdunek was awarded Motorola's patent of the year award in 2002 for a voice-data integration approach that is licensed and extensively used in cellular communications. He holds 17 other patents, included patents used in public safety trunked systems and cellular and trunked systems roaming. He directed the invention and validation of Nextel's iDENR voice-data air interface and IP based roaming approach, and was the principal architect of Motorola's SmartNetR public safety trunking protocol suite. In the 1990's, he directed a Spectrum Utilization and Public Safety Spectrum Needs Projection submitted to the FCC in support of the 700 MHz spectrum allocation for Public Safety. He was awarded the BSEE and MSEE degrees from Northwestern University, and the Ph.D. EE degree from the Illinois Institute of Technology. He is a registered Professional Engineer in the State of Illinois. He is past president, and on the board of directors of the Chicago Public Schools Student Science Fair, Inc.

Mike Needham, Principal Engineer II

Mr. Needham joined Roberson and Associates in November of 2013 with more than 28 years of experience in corporate research and development. His most recent position was Distinguished Member of the Technical Staff in the Applied Research Center at ARRIS (formerly Motorola Mobility / Google). He has worked in a broad range of technologies in the areas of wireless communication and media delivery systems, including: network architecture design, specification, and analysis; data protocol design; radio system modeling; and media analytics. He has 25 issued U.S. patents, with several more pending, and many years of experience in intellectual property assessment and management. Mr. Needham also has numerous publications in technical journals and conferences. He holds B.S. and M.S. degrees in electrical engineering from the University of Illinois in Urbana-Champaign.

Nat Natarajan, Principal Engineer III

Dr. Natarajan earned his B.Tech. from the Indian Institute of Technology (Chennai), ME with Distinction from the Indian Institute of Science (Bangalore) and Ph.D. from the Ohio State University, Columbus, OH. Nat joined Roberson and Associates in 2014 with over 25 years of industry experience in wireless communication and networking systems. Previously he has worked as a Mobility Network Consulting engineer and architect at Cisco Systems (2010-2013), Fellow of the Technical Staff at Motorola (1993-2009) and Research Staff Member at IBM Thomas J. Watson Research Center in Yorktown Heights, NY (1983-1993). Nat is a creative network architect, problem solver and an accomplished master network innovator with work experience covering the entire technology life cycle - pioneering technology research, industry standardization, system architecture, design and

analysis, prototyping and trials, product development and commercial deployment. He began his wireless career at IBM with fundamental contributions to WLAN architecture concepts and specs of the baseline 802.11 standard that have been acknowledged by the IEEE. After joining Motorola he developed the routing algorithms for Iridium, a LEO satellite communication system. He subsequently pioneered and advocated All-IP Packet switching for mobile wireless networks starting with Motorola 4G research (1997). He led the early customer demonstrations of such systems, including VoIP, SIP, Mobile IP and seamless inter-technology handoffs (WiFi and cellular RAN) through a sequence of trials (2000-2002). Nat has 38 issued US patents including several implemented in commercial wireless systems. During2004-09, he led early research and standardization of 802.16e/WiMAX as well as LTE (FDD and TDD). He contributed to development teams in prototyping early implementations of WiMAX and LTE prior to commercial release. His most recent experiences at Cisco (2010-13) include commercial customer deployment of UMTS Femto and Macro LTE systems. Through much of his career, Nat has served as a trusted advisory consultant to C-level executives, network planners and senior technologists of major operator customers across the globe. Nat has 35+ refereed technical publications, 3 Cisco Achievement Awards, Motorola Science Advisory Board Associate recognition, Global Standards Awards for Outstanding Performance and 5 IBM Achievement Plateau awards. Nat is an IEEE Senior Member and its communication society. Additional publication details can be found at: https://www.linkedin.com/in/natnatarajan.

Edward Porrett, Sr. Engineer I

Mr. Porrett is a Senior Engineer I for Roberson and Associates. He has 35 years experience in the research, design and testing of prototype radio communications equipment. Prior to joining Roberson and Associates, he was a Senior Staff Research Engineer at Motorola working in the Research and Development Labs. His experience ranges from working on the first cellular telephone prototype and demonstration system, making early cell system propagation measurements, to managing and operating an antenna test range with international customers. While at Motorola he developed three patents covering diverse fields of RF transmitter improvement, Infra-Red communications, and propagation measurement systems. His expertise is in making and analyzing RF measurements and working with and developing measurement systems. He has an Associate in Applied Science, Electrical Engineering Technology Degree from Michigan Technological University.